Robot Programming #7

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Introduction to analog data

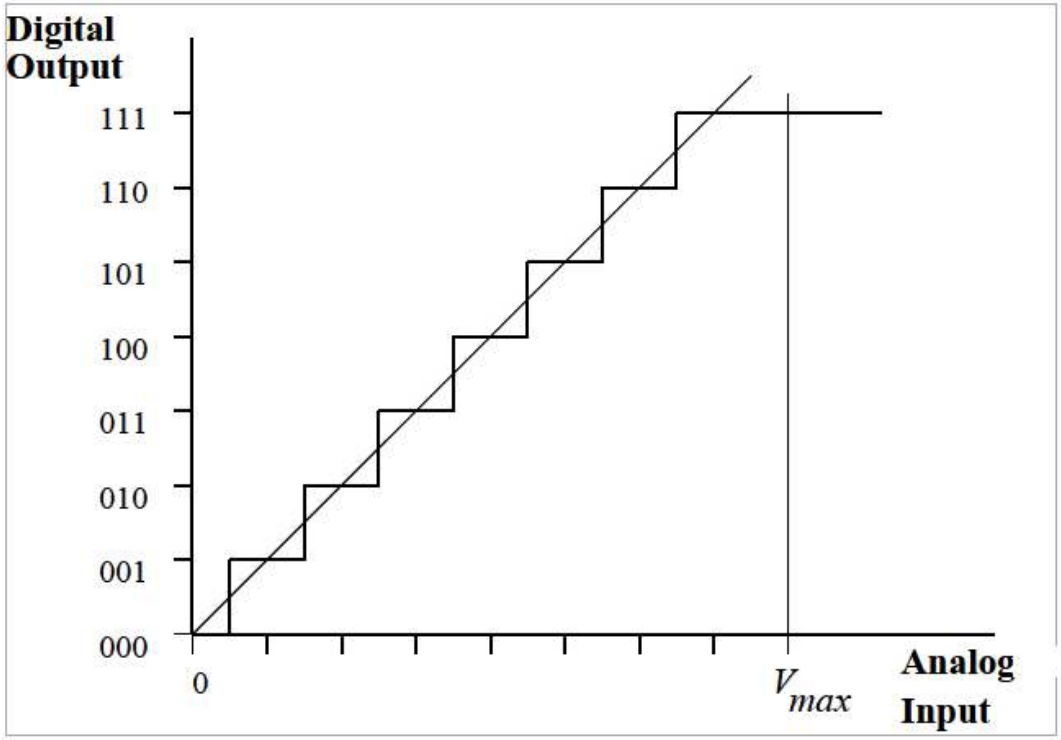
- Microcontrollers are often required to interface with analog signals.
- They must be able to convert input analog signals, for example from microphone or temperature sensor, to digital data.
- They must also be able to convert digital signals to analog form, for example if driving a loudspeaker or dc motor.
- We will first consider conversion from analog-to-digital, before later looking at digital-to-analog conversion.

Concepts of AD conversion

- An analog-to-digital convertor (ADC) is an electronic circuit whose digital output is proportional to its analog input
- Effectively it "measures" the input voltage, and gives a binary output number proportional to its size
- The input range of the ADC is usually determined by the value of a voltage reference

Concepts of AD conversion

- The `staircase' visible in a 3-bit ADC

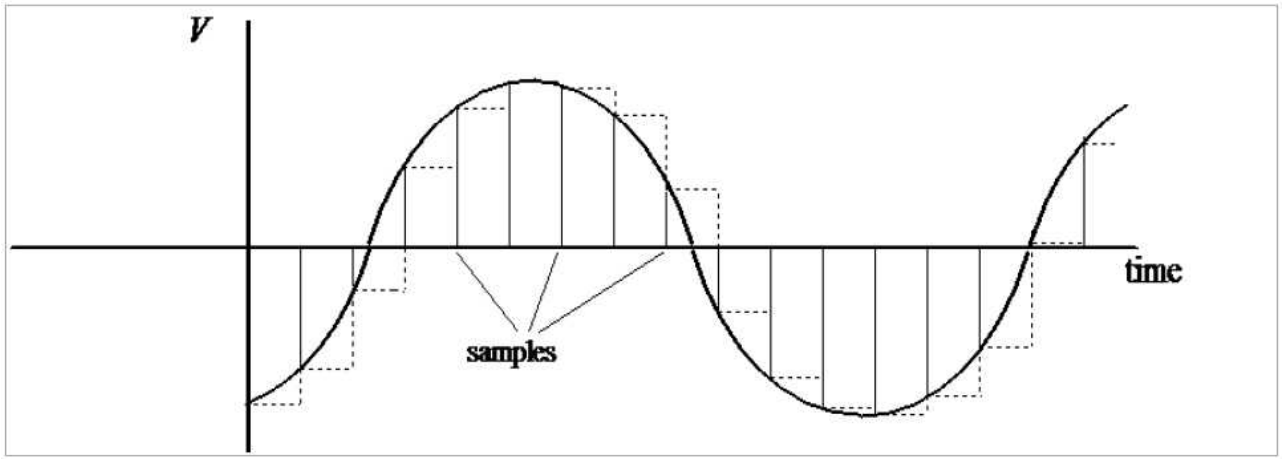


Concepts of AD conversion

- By converting an analog signal to digital, we are effectively approximating it, as any one digital output value has to represent a very small range of analog input voltages, i.e. the width of any of the steps on the “staircase” n.
- If we want to convert an analog signal that has a range 0-5 V to an 8-bit digital signal, then there are 256 (i.e. 28) distinct output values. Each step has a width of 5/256 = 19.5 mV, and the worst case quantization error is 9.8mV.
- The Arduino uses a 10-bit ADC. This leads to a step width of 5/1023, or 0.49 mV; the worst case quantization error is therefore 0.24 mV.

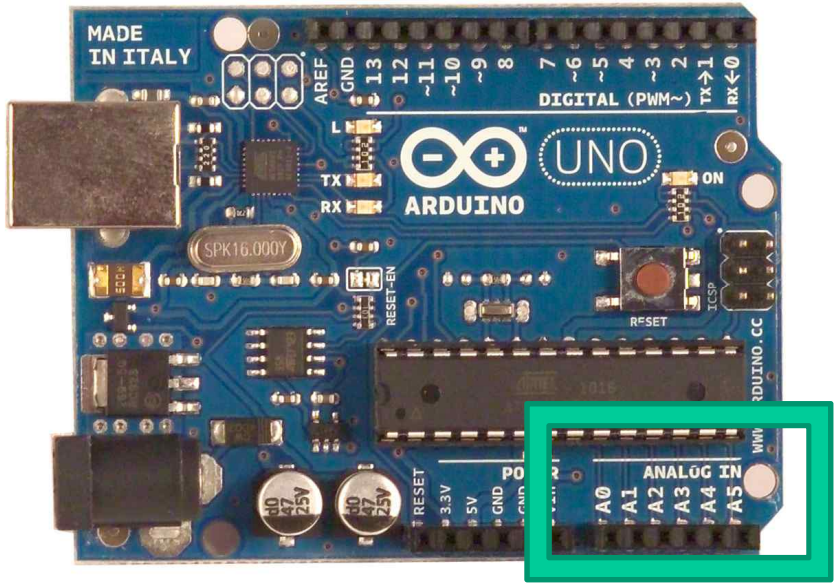
Concepts of AD conversion

- The sample frequency needs to be chosen with respect to the rate of which the sampled data is changing. If the sample frequency is too low then rapid changes in the analog signal may not be obvious in the resulting digital data.



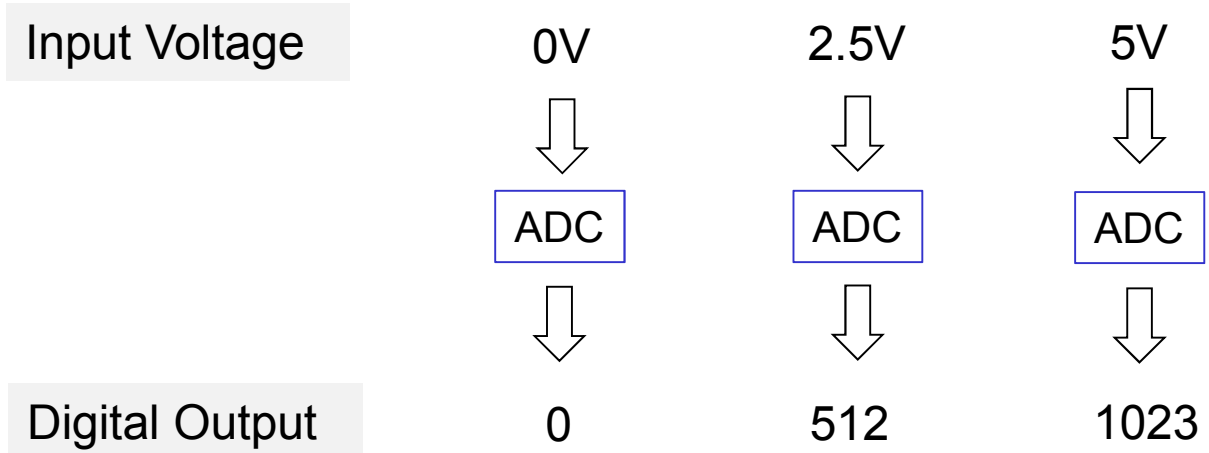
Analog inputs on the Arduino

- The arduino has up to six analog inputs.
- 10-bit analog to digital converter. This means that it will map input voltages between 0 and 5 volts into integer values between 0 and 1023.



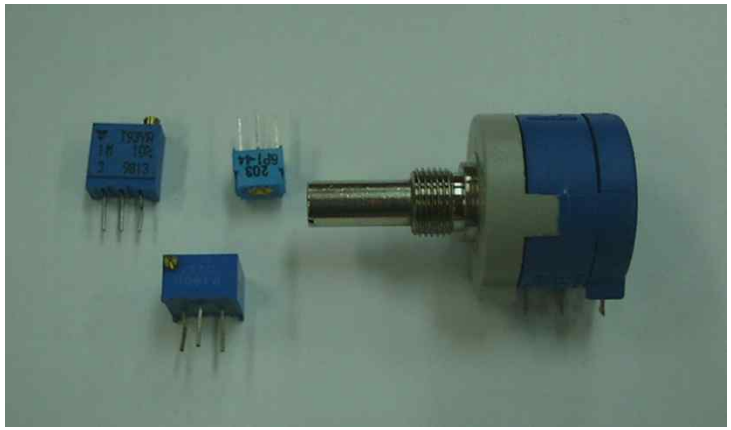
Converting analog value to digital

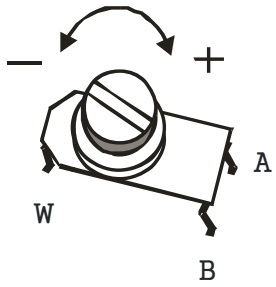
- A/D conversion in the Arduino is carried out as follows:

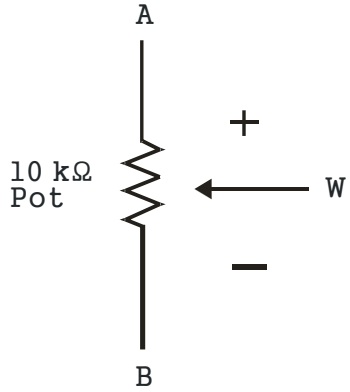


Potentiometer

- The potentiometer is a variable resistor.



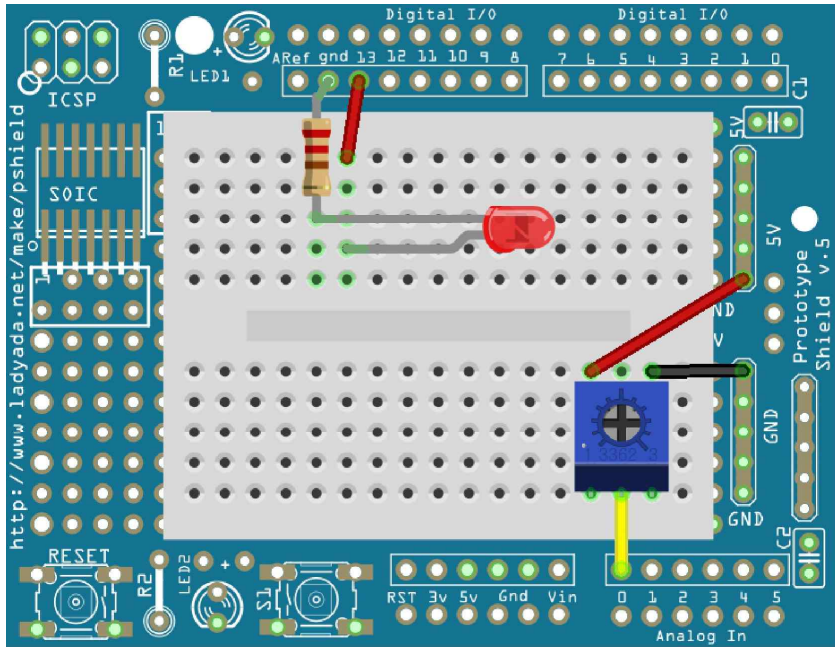


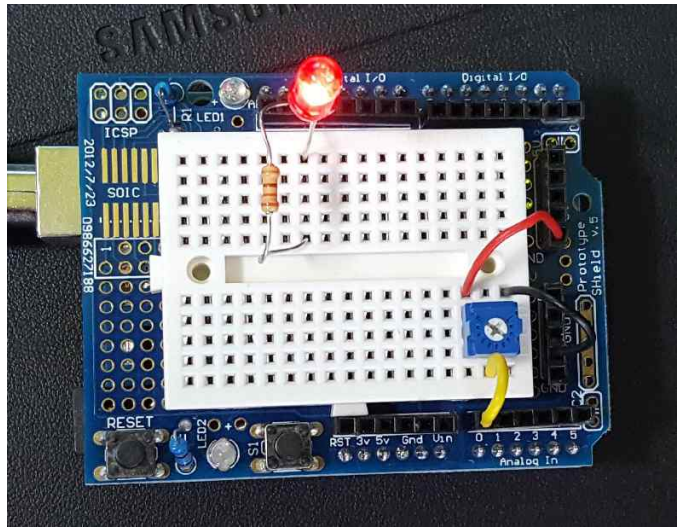


- If A is connected to the voltage source and B is connected to the ground, then the voltage measured at W vary with the angular rotation of the knob.

Connect Pot to the Arduino

- Connect 10k trim pot to the analog input, A0, and LED and resistor(330 Ohm) to pin 13 of the Arduino as shown below.





Reading analog inputs(Pot)

- Program:

```
int sensorValue = 0;

void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  sensorValue = analogRead(A0);
  digitalWrite(13, HIGH);
  delay(sensorValue);
  digitalWrite(13, LOW);
  delay(sensorValue);
}
```

A Closer Look

- Analog value (0-5V) is converted to an integer value (0-1023) by analogRead().

```
int sensorValue = analogRead(A0);
```

- Run the program and see what happens when rotating the trimpot.

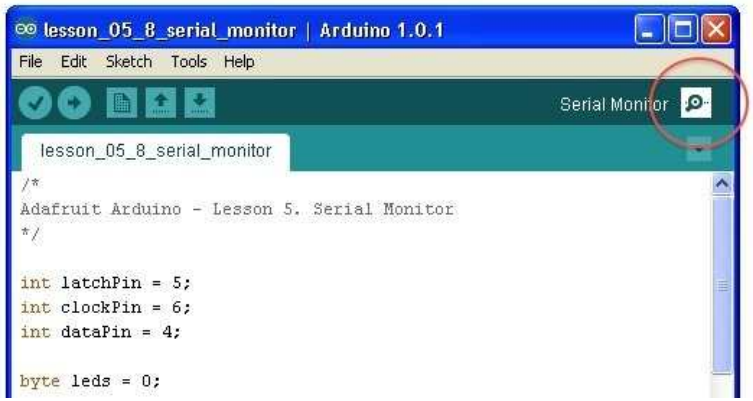
Reading analog inputs(Pot)

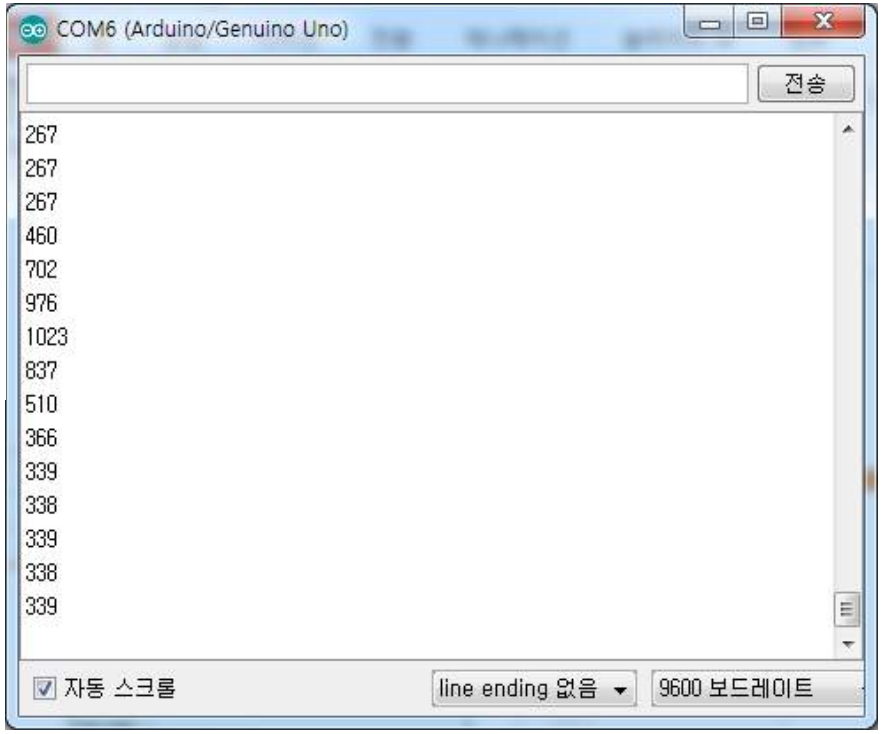
- Let's modify the program by adding two lines.

```
int sensorValue = 0;

void setup() {
  pinMode(13, OUTPUT);
  Serial.begin(9600);
}

void loop() {
  sensorValue = analogRead(A0);
  Serial.println(sensorValue);
  digitalWrite(13, HIGH);
  delay(sensorValue);
  digitalWrite(13, LOW);
  delay(sensorValue);}
```

Reading analog inputs(Pot)

- Clicking the serial monitor, you will see





Arduino serial monitor

- To use the serial monitor, the following must be included in the setup().

```
Serial.begin(9600);
```

- Any value can be monitored by the following function.

```
Serial.println(sensorValue);
```

or

```
Serial.print(sensorValue);
```

Arduino serial monitor

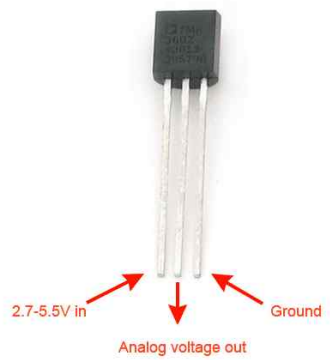
- The Arduino IDE has a feature that can be a great help in debugging sketches or controlling Arduino from your computer's keyboard.
- The Serial Monitor is a separate pop-up window that acts as a separate terminal that communicates by receiving and sending Serial Data.
- Serial Data is sent over a single wire (but usually travels over USB in our case) and consists of a series of 1's and 0's sent over the wire. Data can be sent in both directions (In our case on two wires).

Reading Analog Input(Photoresistor)

- Photoresistor: called a photoresistor, photocell or light-dependent resistor. In fact, this is a light-controlled variable resistor. The resistance of a photocell decreases with increasing incident light intensity; in other words, it exhibits photoconductivity.

Reading Analog Input(Temperature)

- Temperature Sensor, TMP36: a low voltage, precision centigrade temperature sensor. It provides a voltage output that is linearly proportional to the Celsius temperature.



- Voltage Input : 2.7V to 5.5 VDC
- 10 mV/^{o}C scale factor
- Operating Range: -40^{o}C to +125^{o}C